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BIOMETRY AS A METHOD IN TAXONOMY[1]

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We take it for granted that the systematic description of plants, and animals, is not the province of the amateur, however interested he may be in a special group of living things. To the contrary this work should be done by the professional botanist, or zoologist, and demands a high grade of trained skill and judgment. More intelligence is needed than suffices to carefully fill out a card for a catalog, and yet how often do we find descriptions of species that would be discreditable to even a librarian's assistant!

The characters of one species are sometimes described as ''smaller,'' ''longer,'' ''darker'' or ''lighter'' than those of another, but upon reading the description of the other species referred to, the characters are again equally lacking in exactness. It is useless to enlarge upon this item, for every naturalist is sadly familiar with such imperfect and inadequate descriptions.

Biometry offers a method of great value for the study of specific characters, and the consequent clear and definite statement of the results of such study. There are workers either frightened at the mathematics of the method, or scornful of the whole thing on the general principles of conservatism, or prejudice. The mathematics of biometry, considered merely as a biological working method, is that of simple arithmetic, with no operation more complicated than the extraction of the square root.

It is certainly of great advantage to record in the standard deviation an exact mathematical statement of the variability of a character in place of the sometimes utterly meaningless, or again only partly useful, qualitative phrases which may be given. The correlated variability of some of the characters is important. Descriptions based on the mean and range of variation of each character and so expressed are better than those based on values taken here and there at random and then, when once published, petrified into a specific type ideal. A naturalist later tries to identify a specimen with this very limited description, but the characters of the specimen are too divergent and so a new species is created. Still later another naturalist works with a hundred specimens, including the characters given for the two preceding species, and then synonymy is born and with it trouble forevermore.

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[1] Read at the Seventh International Zoological Congress, Boston, August, 1907.

As an illustration of the usefulness of biometry for the solution of taxonomic problems I may take the case of the common Florida-Caribbean holothurian described in 1851 by Pourtalès as *Holothuria floridana.* In 1868, Semper considered this species identical with *H. atra* Jäger, 1833, from the Celebes. All authors have followed Semper to the date of my publication (1905). In the meantime Ludwig, in 1883, recognized a species in the West Indies different from the Indo-Pacific form and failing to identify it with *H. floridana* Pourtalès, created a new species, *H. mexicana.* The same error was repeated by Theél, in 1886, in making his *H. africana.*

With a feeling that things were not as currently accepted, I concluded to apply the method of biometry to this problem. From the United States National Museum, Harvard University, and my own collections, 138 specimens, covering nearly the whole geographical distribution of the two species were available for the work. In the solution of the general problem before me no attempt was made to determine place modes of which, in minor details, there were sometimes indications. Every important character was submitted to statistical study and the result is that *H. floridana* Pourtalès is reestablished as a valid species, with *H. mexicana* Ludwig and *H.*

africana Theél as synonyms. The old characters have been redefined, new ones added, and those differentiating *H. atra* and *H. floridana* clearly stated. The young and old have been segregated and differentiated and the results of growth determined. The nature and extent of the variation of each character has been recorded. An entirely new character for holothurians has been discovered in what I have called "pits," in the body-wall of *H. atra.*

It is not possible in taxonomic work to give several years to the study of each species and it often happens that the material is not sufficient. If an author will make a thorough biometric analysis of the characters of at least one species in his group, he will gain a rare insight into the relative values of the characters. The method is searching and leads to especial carefulness in investigation and statement. Even if one has not an ideal number of specimens his determinations are checked by their probable errors. In the case of some characters, as for instance, the spicules of holothurians, an abundance of material is present in each specimen. More and more of the anatomy becomes involved as the work progresses. Now that the individuality and continuity of the chromosomes has been demonstrated, McClung has suggested that their number and grouping constitute family, generic, and specific characters of just as definite worth as those that heretofore have been employed. The more characters studied the better, and the ideal taxonomy will be based upon the whole life-history. Then the error of describing the young and old of a species as independent species will not be repeated.

It naturally follows from biometric analysis that a group of individuals, giving as much as possible of the range in variation, should be established and deposited, preferably in a national museum, as the specific type group rather than some arbitrarily selected type specimen. We have instances of specific descriptions based upon one individual, with an apology by the author for the lack of anatomical details because he could not dissect the one precious specimen!

The best way to avoid trouble in taxonomy is to begin with making the original description as complete as possible. It is then a simple matter to condense for practical diagnostic purposes. The biometric determination of the variability of the different characters allows of their arrangement in the order of increasing variability and will perhaps demonstrate which are the "best" characters. It is too soon to state exactly what percentage of divergence justifies the creation of a variety, or of a species, and it is not probable that any universally applicable measure will be established.

Biometry gives us data of value bearing upon one or more of the factors of evolution and records them in the best form for use. We know that under varying environmental conditions different varietal, or specific forms respond. The new forms may be only temporary and followed by still other new forms, under other changed conditions, or with reversion, when the old conditions are restored. Characters, whether expressed in the terms of biometry, or not, are not permanently fixed by the publication of a specific description. It is to be hoped that the spirit of Darwin is with us yet and that we realize that species are in a state of evolution, either continuously or discontinuously, slowly or rapidly. If we are to follow species in their evolution we must have exact and comprehensive statements of their characters from time to time as it is possible, and, if in the terms of biometry, these statements are always in harmony and comparable.

If then, while performing the necessary work of taxonomy, we can make our descriptions more complete and nearer the truth; if occasionally we may be relieved of the necessity of creating a new species; if our work may contribute to the advancement of the philosophy of biology, should we not welcome biometry as a method which can well serve in one and all of these things?